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BUILT-UP ROOF CONSTRUCTION QUALITY CONTROL.(U)
JUL 79 E S LINDOW, E MARVIN, M J ROSENFIELD

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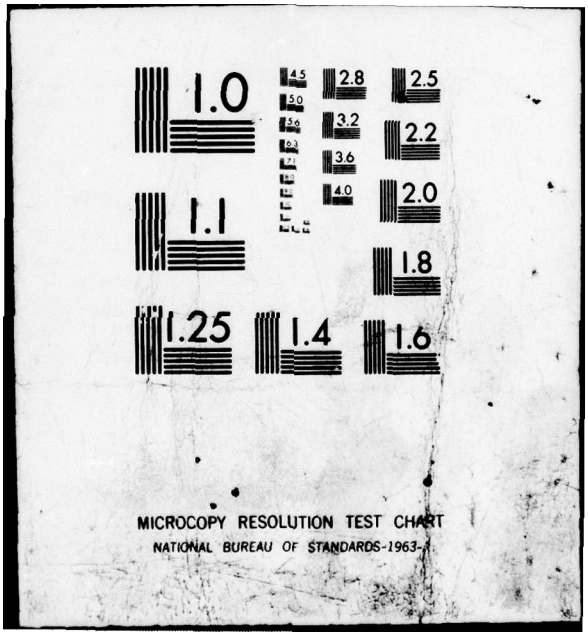
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TECHNICAL REPORT M-267
July 1979

BUILT-UP ROOF CONSTRUCTION QUALITY CONTROL

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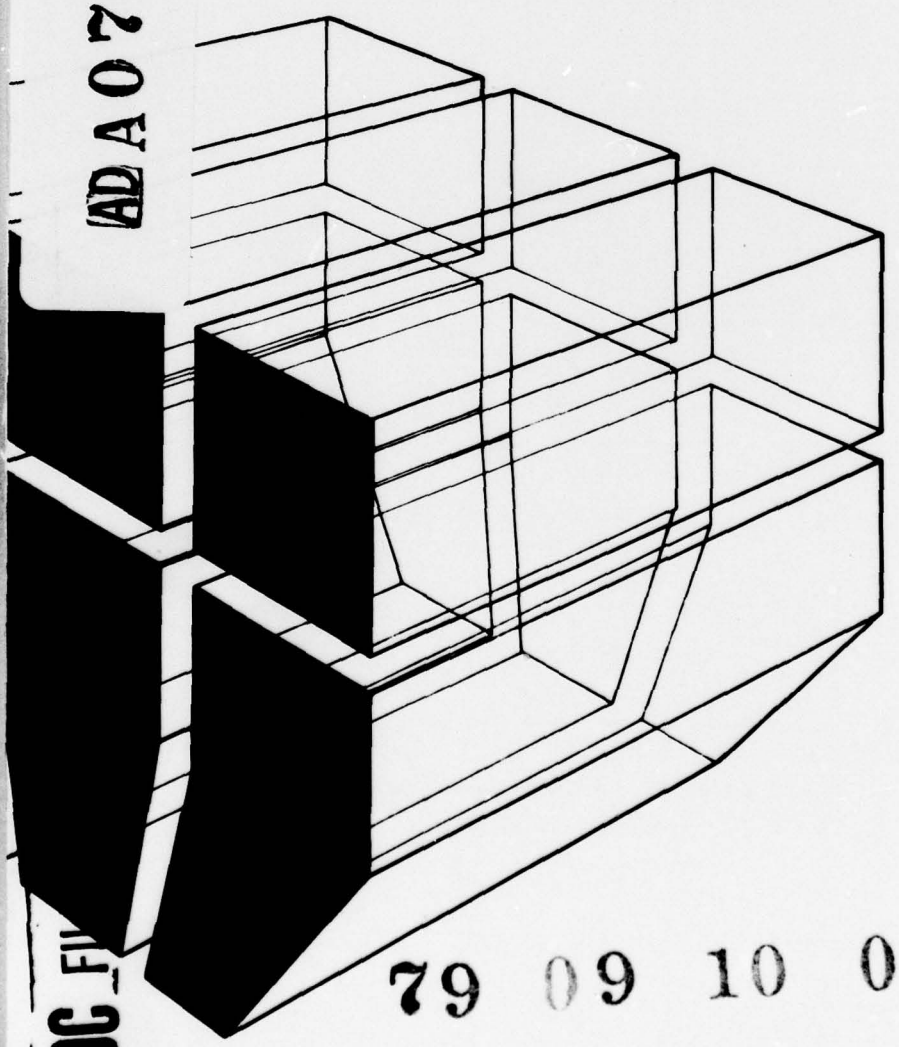

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This report recommends ways to improve the performance of built-up roofing in Army facilities by advancing roof construction quality control and quality assurance. This study assessed the state of the art in roofing quality control; evaluated existing Army Corps of Engineers quality control/quality assurance requirements related to roofing; examined the Corps' current roofing practices to determine compliance with the state of the art and Corps requirements; and provided the recommendations based on assessments of current performance.

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FOREWORD

This work was conducted for the Directorate of Military Programs, Office of the Chief of Engineers (OCE), under RDT&E Army Program 6.27.31A; Project 4A762731AT41, "Design, Construction, and Operations and Maintenance Technology for Military Facilities"; Task T7, "Military Construction Materials"; Work Unit 009, "Built-Up Roof Construction Quality Control." The applicable QCR is 3.07.028. The OCE Technical Monitor was Mr. John Ichter, DAEN-MPE-S.

Messrs. J. R. Keeton and R. L. Alumbaugh of the U.S. Navy Civil Engineering Laboratory are acknowledged for their contributions to this project, specifically the information provided in Appendix A. Information provided by personnel at Army Corps of Engineers Division, District, Area, and Field levels and commentary provided by Messrs. J. Ichter and R. Seaman are also acknowledged.

The work was performed by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL Principal Investigators were Dr. P. A. Howdyshell, Mr. E. S. Lindow, and Dr. E. L. Marvin. Dr. G. R. Williamson is Chief of EM.

COL J. E. Hays is Commander and Director of CERL, and Dr. L.R. Shaffer is Technical Director.

CONTENTS

BUILT-UP ROOF CONSTRUCTION QUALITY CONTROL

1 INTRODUCTION

Background

In building construction, the roof is second in importance only to the foundation. However, while the foundation and other structural members are designed to preclude failure, the roof is expected to serve for only a portion of the building's life. As a result, many users have accepted service lives of roofs which are less than the state of the art can provide. Although the anticipated life for built-up roofing (BUR) in military buildings is generally 20 years, recent studies[1,2] have shown the average life to be 12 years or less. This increasingly poor performance has been attributed to many factors, including:

1. Quality of workmanship
2. Quality of manufactured materials
3. Inadequate design
4. Pressure from users to meet deadlines
5. Incompatibilities in specifications and drawings
6. Ambiguities in specifications
7. Lack of maintenance.

These problems have caused high maintenance and repair costs for BUR at permanent Army installations. It is therefore necessary to improve the Army's current methods of quality control/quality assurance of BUR to decrease these costs.

Objective

The objective of this study was to recommend measures for advancing roof construction quality control/quality assurance to improve the performance of BUR on Army facilities.

[1]Torillo, M. R., Memorandum, Subject: SAC Roof Management Program, HQ SAC/DEMM (1977).

[2]Keeton, J. R., and R. L. Alumbaugh, *Roofing Survey of Naval Shore Bases*, Technical Memorandum No. 52-77-3 (Naval Construction Battalion Center, Civil Engineering Laboratory, March 1977).

Approach

This study (1) assessed the state of the art in roofing quality control; (2) evaluated the Corps' existing requirements (i.e., regulations and specifications) relating to roofing quality control/quality assurance; (3) examined the Corps' current roofing practices through field studies to determine compliance with the state of the art and Corps requirements; and (4) recommended possible modifications to the Corps' quality control/quality assurance program.

Scope

Although regulations governing the Corps' quality control/quality assurance program relate to all types of construction, this study is concerned only with built-up roof construction. Therefore, the findings and recommendations are limited in application to roof construction projects. Extrapolations to other construction entities are possible; however, their implementation should be the subject of separate studies.

Mode of Technology Transfer

The recommendations will be implemented by modifications to EP 415-1-262, *Construction Inspector's Guide*, and by either (1) an Engineer Technical Letter or an Engineering Improvement Recommendation System Bulletin provided to Corps District offices and construction field offices, or (2) modifications to Corps of Engineers Guide Specification 07150.

2 QUALITY CONTROL OF BUILT-UP ROOF CONSTRUCTION

State of the Art

Background

Several persons are responsible for providing a BUR system which will remain serviceable and require minimal maintenance throughout its design life; the user, designer, general contractor, mechanical and plumbing contractors, roofing materials manufacturer, decking manufacturer and installer, inspection force, and roofing contractor all share the responsibility for providing a good roof. Unsatisfactory performance by any of these individuals will result in an inferior roof system, regardless of the quality of materials and workmanship the others provide. Although quality control is generally attributed to the field inspection force, this function alone cannot guarantee BUR serviceability.

Traditionally, architects and engineers have relied on the roofing industry to assure quality roofing

guarantees or bonding. As BUR became more popular after 1900, the manufacturers satisfied this requirement by (1) developing specifications and rigid standards of workmanship for installing their materials, (2) providing trained inspectors to assure contractor compliance, and (3) licensing use of their materials only to those contractors who would adhere to their specifications and standards. Since BUR was apparently performing satisfactorily and the manufacturers were accepting responsibility for the performance of bonded roofs, the owners, designers, and contractors were less concerned with controlling the quality of BUR.

Following World War II, however, the practice of licensing roof contractors was declared an illegal restraint of free trade. The post-war building boom created a market which attracted new roof material manufacturers and stimulated a tremendous growth in the number of roofing contractors. As a result, the manufacturers were no longer able to provide the former type of quality control. In many instances, the manufacturers were presented with a conflict of interest—should application standards be relaxed to sustain sales volume, or should the quality of the end product be retained at the risk of losing work to others?

Many other factors influenced BUR's increasingly poor performance. Users demanded quick completion of roofing and placed a premium on lowest initial cost. Designers did not always recognize or specify quality roofing. New roofing materials and construction were inadequately tested, and few performance records were available. The quality of workmanship decreased as roofing crews became less skilled. Users and designers were unsure about how to establish BUR quality control standards, because of their previous reliance on the manufacturers.

BUR Inspection

Although better roofing systems and materials have improved methods of controlling a building's interior environment, the methods used for controlling roof installation generally have not improved. The inspection of other building components uses nondestructive testing techniques and quantitative criteria to measure quality, e.g., density of foundation soils, bearing capacity of piles, and strength of structural steel and concrete. However, in roofing, inspection relies principally on visual observation. Thus, the quality of roofing inspection is directly dependent on the inspector's expertise.

The roof cut remains the principal inspection tool for validating compliance with specifications. This procedure uses 1 sq ft (.09 m^2) sample cut from the completed roof. Quantities of surfacing, bitumen, felts, and insulation can be measured and compared with specifications. The inspector can examine the plying of felts, the interply mopping, and, if necessary, the condition of the deck. However, there are several drawbacks to testing roofs by examining cut-out samples, including:

1. The test is destructive; a point of weakness can be introduced into the system if the roof cut is patched inadequately.

2. The test is made after installation; i.e., deficiencies are identified after the system is installed rather than while the work is done.

3. The cut is a sample and therefore presents the inherent dilemma of sampling, i.e., how frequently to sample and how to extrapolate sample results over the whole system.

Recently, inspectors have used nondestructive means of determining moisture within BUR systems. However, for any type of moisture detection equipment to be useful, quantitative criteria must be established for defining tolerable moisture contents in insulation, felts, and the whole system.

Other areas of investigation which may eventually improve the quality control of BUR construction include the development of performance criteria[3] and the proposed adoption of Equiviscous Temperature (EVT) as a measure of the proper temperature for mopping bitumen.[4] However, further development and the production of testing equipment for field use are required before these criteria can be implemented as construction quality control tools.

Since BUR quality control inspection is basically subjective, rather than objective, the inspector's training and experience are paramount to effective quality control.

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[3]Mathey, R.G., and W.C. Cullen, *Preliminary Performance Criteria for Bituminous Membrane Roofing*, Building Science Series 55 (National Bureau of Standards, November 1974).

[4]*Equiviscous Temperature (EVT)*, Technical Developments Bulletin No. 2 (National Roofing Contractor's Association, December 15, 1977).

Types of QC Inspection

It has been argued that the responsibility for quality control lies with the user, since the user ultimately pays for this service. However, this responsibility is frequently delegated to the designer or to the contractor because of the user's lack of manpower or experience. The following methods of quality control inspection can be used:

1. In-house inspection—inspectors are the user's employees and are solely responsible to the user.

2. Consultant inspection—inspectors are employees of an independent consulting or testing firm specializing in roof quality control; the client may be the user, the designer, or the contractor.

3. Contractor inspection—inspectors are employees of the contractor and are usually directly responsible to the firm's management and not to the job's superintendent.

Any of these methods can be successfully used to insure that construction complies with the specifications. However, for these methods to succeed, all members of the building team must cooperate, coordinate tasks, and be competent.

Existing Corps of Engineers Requirements

The Defense Acquisition Regulation (DAR*) 7-602.10(a) authorizes Department of Defense agencies to require contractor quality control (CQC) on construction projects. This regulation resulted from the adoption of the following contract General Provision clause by the ASPR Committee in 1961.

> The contractor shall (i) maintain an adequate inspection system and perform such inspections as will assure that the work performed under the contract conforms to contract requirements, and shall (ii) maintain and make available to the government adequate records of such inspections.[5]

The Corps of Engineers enacted CQC through ER 1180-1-6[6] in 1971. This regulation applies to all construction contracts of more than $10,000 awarded and supervised by Corps Districts or Divisions. Since the regulation applies to all types of construction, the Contracting Officer of each project is charged with preparing (1) contract special provisions which ". . . establish the requirements for a Contractor Quality control program. . . ." and (2) contract technical provisions which ". . . establish the level of quality required and should clearly state the specific inspections and tests the contractor will be required to perform to maintain quality control." In this manner, each construction project should have a CQC program tailored to its needs.

Responsibilities of the contractor and the Government are defined in ER 1180-1-6 as follows:

Quality Control (QC)—the contractor's responsibility in producing construction complying with contract requirements.

Quality Assurance (QA)—the Government's responsibility in assuring that the contractor's QC is achieving the desired results.

This regulation also gives detailed requirements for a preconstruction conference, the contractor's quality control plan, QC/QA activities during construction, CQC reports, and enforcement of the CQC. Although quite comprehensive, ER 1180-1-6 does allow the involved parties some latitude in format and in the specific content of the CQC plan and QC reports. Because of this regulation, most of the preconstruction conference is usually spent in discussing the CQC plan, as well as the contractor's safety plan, insurance, performance bond, and other DAR requirements. Actual technical matters, if discussed, are seldom examined thoroughly. The contractor is assumed to have read and understood the specifications, but this assumption is often proved wrong when actual construction is performed.

Other publications which govern or relate to construction quality control on Corps projects include:

ER 415-1-10 – *Contractor Submittal Procedures*[7]

ER 415-1-302 – *Inspection and Work Records*[8]

*Formerly ASPR.

[5] Stephen, L. M., *Construction Quality Assurance* (South Atlantic Division, U.S. Army Corps of Engineers, July 1970).

[6] *Construction Quality Control*, ER 1180-1-6 (Office of the Chief of Engineers [OCE], 10 October 1972).

[7] *Construction Contractor Submittal Procedures*, ER 415-1-10 (OCE, 16 July 1973).

[8] *Construction Inspection and Work Records*, ER 415-1-302 (OCE, 1 February 1977).

EP 415-1-260 – *Resident Engineer's Management Guide*[9]

EP 415-1-262 – *Construction Inspector's Guide.*[10] This publication was last revised in 1965, and reflects the guide specifications as they existed at that time. Many of its instructions to inspectors no longer apply, and some are in actual conflict with current guide specification requirements.

3 FIELD SURVEY FINDINGS

Current QC/QA practice was evaluated during FY78 for nine Corps of Engineers roofing projects. The evaluation included discussions with Division, District, Area, and Field personnel, as well as observations of actual practice. This chapter summarizes findings of the evaluation, and Appendices A and B provide detailed data from three sites.

Discussion Topics

The following pertinent topics were discussed with Division, District, Area, Resident Engineer, QA, and QC personnel:

Is Full-Time Inspection Required?

At present, full-time, in-house inspection is not being practiced by any of the Divisions contacted. Most comments indicated a preference for full-time inspection; however, there is a pragmatic belief that Corps staffing levels will preclude having qualified, full-time inspection on roofing projects.

What Training Is Provided in Built-Up Roofing?

Only one District responded that it had a good training program with a set of training documents. Others indicated that inspectors were trained informally; that OCE school was used as a basis of training; that inspectors were provided with schooling in roofing whenever possible; and that reference documents such as *Manual of Built-Up Roofing Systems,*[11] *NRCA Roofing Manual,*[12] and EP 415-1-262 were required reading for inspection personnel.

What Criteria Are Required for CQC Plans?

Generally, the CQC plan for each project is viewed individually. Although individuals responsible for reviewing and accepting the CQC plans have personal preferences in a plan's composition and comprehensiveness, none of the organizations contacted had formal checklists or criteria for CQC plans. All organizations contacted rely on DAR 7-104.24, ER 1180-1-6, and the General Provisions, paragraph 11, for guidance. However, there is no standard format for CQC reports.

Are QC or QA Checklists Required for Inspectors?

The organizations responding positively generally used a checklist contained in EP 415-1-262. The majority of those contacted felt checklists would be useful, and one Division has already begun development of a checklist.

Is Third-Party QC Used?

The performance of quality control by an independent consultant is not in general use, although two projects under way during this study were using an independent consultant for QC. Although most District and Division personnel believed the concept to be useful, they wanted to judge projects individually to determine when to employ an independent consultant. Some Districts, in anticipation of using third-party QC, are developing lists of qualified inspection agencies. One Division also related successful use of an independent consultant for QA.

How Are Authorities and Responsibilities Defined for QC and QA?

All respondents stated that QC and QA responsibilities are as defined in ER 1180-1-6. The requirements of this ER are included in each project's contract documents. The consensus was that responsibilities are adequately defined and contract requirements are being enforced at each level. Undue pressure by the next higher echelon was not a problem. Generally, each level felt that the next higher echelon did provide the necessary reinforcement of authority. Some of the QC and QA field personnel did feel that to expedite construction, Government inspectors should have, or exert, more authority in the interpretation of specifications. Also, respondents indicated that stricter enforcement of contract specification provisions, up to

[9] *Resident Engineer's Management Guide,* EP 415-1-260 (OCE, 15 October 1973).

[10] *Construction Inspector's Guide, Architectural and Structural Features in Building Construction,* EP 415-1-262 (OCE, June 1965).

[11] Griffin, C. V., *Manual of Built-Up Roof Systems* (American Institute of Architects, 1970).

[12] *Roofing Manual* (National Roofing Contractors Association, 1976).

and including litigation, was mentioned as a necessity to achieve good workmanship.

What Are the Most Persistent Contract Violations?

The most persistent contract violations cited were excessive bitumen temperature in the kettle; bitumen temperature too low at point of application; deviations from good roofing application practice (e.g., use of brooming felts and protection of completed work); use of incorrect materials; beginning roofing without sufficient materials on site; and incorrect quantity of bitumen applied. Also cited was staged construction, the application of a glaze coat, with the flood coat and aggregate surfacing completed on a subsequent day. Although generally contrary to specification, staged construction was not universally considered a deviation from good roofing practice.

How Can Violations Be reduced?

The consensus was that contract violations could be greatly reduced by full-time, experienced inspection. Inspectors could be either in-house personnel or consultants contracted by the Government to provide QC. A tangential recommendation was to retain the CQC but provide full-time, trained QA inspectors on selected large or unique projects.

Other specific recommendations included requiring a chart temperature recorder on all kettles; specifying application temperatures by the equiviscous temperature; using a moisture survey for final acceptance of construction; and establishing calendar cut-off dates for roofing construction.

Field Observations

Specifications were reviewed and QC/QA practices observed for selected projects. These finds are summarized below.

Specifications

Specifications for 15 Corps of Engineers roofing projects were reviewed. These projects were geographically dispersed throughout the continental United States and Alaska. All of the specifications required construction quality control as stipulated by ER 1180-1-6. Generally, the specification sections covering QC/QA were similar in format, with differences being principally editorial. The exceptions were those specifications for Army Reserve Center construction which used an abbreviated CQC format.

Table 1 lists typical discrepancies or deficiencies found in the contract specifications reviewed. Table 2 lists typical differences between the contract specifications and guide specifications.

Table 1
Discrepancies and Deficiencies
Within Contract Specifications

a. **Insulation**

(1) Base sheet is specified in applicable publications, but no instructions for installation are given in specifications nor details shown on drawings.

(2) Instructions are given for application directly to steel decks, but no such application exists on the job.

(3) Instructions are given for application to concrete deck, but no such application exists on the job.

(4) Felts are referenced, but none are used with insulation.

(5) Cants are specified as being made of impregnated fiberboard and having a 5 1/2-in. (140 mm) face. Drawings indicate no size made of wood, 4 in. (100 mm) made of metal, and 6 in. (150 mm) prefabricated of unspecified material.

(6) Reference is made to Factory Mutual Bulletin 1-28, but it is not listed in applicable publications.

b. **Roofing**

(1) Mineral-surface roll roofing is specified in applicable publications, and storage instructions are specified, but no instructions for installation are given in specifications, nor details shown on drawings.

(2) Instructions are given for installation of asphalt plank walkway treads, but no material specifications are listed and no location is shown on the drawings.

(3) Base sheet was installed at the job, but no instructions are given in the specifications for use or installation.

(4) Type of nails is specified for fastening roofing to deck; how they are used is specified but not where they are used. The only instructions for actual nailing are for base flashings on vertical surfaces and for edge envelopes. Nothing is specified for nailing base sheet.

(5) Specifications require two-course base flashing. Drawings show five-course base flashing. Contractor was instructed to install two-course type.

(6) Specifications call for five-ply roof in one paragraph, three-ply in another, and the lap table specifies lap for five-ply roof. Contract was amended to specify four-ply roof.

(7) No contracts specify how to replace samples when removed.

(8) Specifications state cleats are to be installed where specified or required. No other mention of cleats exists in the specifications, and none are shown on the drawings.

(9) Type I asphalt is specified. Roof slopes are 5/8 in. per foot (52 mm/m), but this is not shown on the drawings. Contract was modified to use Type III asphalt.

Table 2
Differences Between Contract Specifications and Guide Specifications

a. **References**
(1) CE-220.12 (June 1968), *Built-Up Roofing* (Obsolete)
(2) CE-220.12 (15 April 1976), *Built-Up Roofing* (Interim)
(3) CE-220.11 (15 April 1976), *Insulation* (Interim)
(4) CEGS 07241 (July 1977), *Insulation* (Latest)
(5) CEGS 07510 (July 1977), *Built-Up Roofing* (Latest)
(6) CE-220.08 (March 1969 and N32 December 1977), *Sheetmetal Work*
(7) CE-R-07.3 (July 1976 and N1 July 1977), *Insulation and Roofing*
(8) CE-R-07.4 (July 1976 and N1 July 1977), *Sheetmetal Work*

b. **Insulation**

Contract Para.	Contract Specification	Interim Guide Specification Para.	Interim Guide Specification Specification	Latest Guide Specification Para.	Latest Guide Specification Specification
2	Materials to be stored in approved manner	2	Materials to be stored in approved manner	2.1	Stored in enclosed building or trailer
2	Bitumen hot when applied	2	Application temperature per insulation manufacturer's recommendation	2.3.3	Application temperature per insulation manufacturer's recommendation
2	Store felts on end 24 hours before laying	2	Store felts on end 24 hours before laying	2.1	Store felts on end at all times
7	Use cutoffs at end of each day's work	7	Use cutoffs at end of each day's work	7.3	Same, plus also when rain is imminent
2	Apply bitumen to steel deck by machine only	2	Apply bitumen to steel deck by machine only	7.1.3	Apply bitumen to steel deck by machine whenever possible
	No requirement for adherence to deck		No requirement for adherence to deck	7.1.1	Insulation which can readily be lifted is not secure

c. ***Roofing***

Contract Para.	Contract Specification	Interim Guide Specification Para.	Interim Guide Specification Specification	Latest Guide Specification Para.	Latest Guide Specification Specification
2	Materials to be stored in approved manner	2	Materials to be stored in approved manner	2.1	Store in enclosed building or trailer
2	Store felts on end 24 hours before laying	2	Store felts on end 24 hours before laying	2.1	Store felts on end at all times
5	Bitumen to be hot when applied	5	Temperature as recommended by felt manufacturer	5.2.4	Temperature as recommended by felt manufacturer
5	Phased construction not permitted. No mention of immediate roof application	5	Phased construction not permitted. Roofing to follow insulation immediately as a continuous operation	5.1	Roofing to follow insulation immediately as a continuous operation
8	Remove excess aggregate from storage areas	8	Sweep surface and remove all loose aggregate	10	Sweep surface and remove all loose aggregate

NOTE: Ref a(1) included instructions for replacing samples cut from roofing; these do not appear in Refs a(2) or a(5).

The review indicated a greater need to coordinate specifications with plans, as well as a need to tailor specifications to the project (e.g., delete extraneous material such as aggregate on a smooth surfaced roof). In addition, items in the specification that will not be enforced during construction should be deleted [e.g., aggregate surfacing the same day as membrane completion and storage of felts above 50°F (10°C) for at least 24 hours before placement]. This does not imply that the exemplified items are unnecessary, but rather that if they are stipulated in the specification, they should be enforced.

The review indicated that to some extent, contract specifications are copied directly from Guide Specifications without thoroughly editing out the statements that do not apply to the specific contract (see Table 1). The Guide Specifications contain instructions relative to removing inapplicable portions when preparing contract specifications, but it is the responsibility of the contract specification writer to read the notes and follow them.

Division and District engineering personnel expressed much concern about the requirement that insulation be furnished to provide a specified heat transmission coefficient, or U-value, without specifying a limit to the thickness. While this may not be impor-

tant for the roof in general, it becomes critical at the edge of roofing along parapet walls and where drains and other roof penetrations are located. Instances were observed where insulation supplied by the contractor was so thick that there was not enough room between the ridge of the roof and the top of a parapet to allow installation of a cant, and proper flashing became impossible. Thus, a built-in potential leak was provided in an otherwise sound roof.

A task committee of the ASCE Construction Division conducted an industry survey to measure the applicability of CQC to nongovernment projects.[13-15] Findings relating to designer and contractor evaluation of CQC specifications were reviewed to provide background for subsequent development of recommendations for improved roofing quality control. Pertinent responses for this survey were:

1. Both designers (A/Es) and contractors felt that construction inspection was desirable.

2. Designers felt that accomplishing design intent was the primary purpose of inspection, while contractors thought that certification of work was the primary purpose.

3. Owners are aware of the importance of inspection, but are not always willing to pay for it.

4. Designers estimated that the typical cost of inspection is approximately 2 percent of contract award price.

5. Designers felt that if CQC were employed, the warranty should be extended to 3 years.

6. Fifty-six percent of contractors did not want the responsibility of inspection.

7. A list of contractor comments on "unfair, annoying, and meaningless provisions in specifications" included:

a. Many specifications are poorly written, ambiguous, obsolete, unclear, and irrelevant.

b. "As directed by the engineer" and "or equal" clauses were criticized as having no meaning.

c. Specifications should be performance oriented, rather than prescriptive.

d. Specifying obsolete or unavailable materials or methods should be avoided.

e. Unreasonable tolerances or lack of allowable tolerances should be avoided.

f. A "shotgun" approach should not be used in writing specifications (i.e., avoid inclusion of inapplicable material in specifications).

QC/QA Practice

The following findings are based on QC/QA practice as observed during the field survey. Although the majority of observed practices were acceptable, the comments listed here concentrate on negative aspects in order to indicate where improvements can be made.

1. QC and QA personnel did not always understand either their own or each other's functions and responsibilities.

2. QC reports often satisfied the contractual requirement for a daily report, rather than documenting the project's quality control.

3. QA personnel are often responsible for several projects, which can severely limit the amount of time spent on each job.

4. Construction pace and scheduling sometimes preclude obtaining construction decisions from Contracting Officers.

5. There was generally a lack of training in the QC and QA objectives and requirements for BUR. The QC personnel were generally knowledgeable in traditional roofing, but not in quality control practice, while the QA personnel were not always sufficiently trained in roofing practice because of the diverse workload handled.

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[13]Dean, J. C., et al., *Contractor Quality Control,* ASCE Journal of the Construction Division, Vol 102, No. C03 (American Society of Civil Engineers [ASCE], September 1976), pp 535-546.

[14]Fisk E. R., *Designer Evaluation of Contractor Comments on Specifications,* ASCE Journal of the Construction Division, Vol 104, No. C01 (ASCE, March 1978), pp. 77-83.

[15]Nugent, M. C., *Evaluation of Contractor Comments on the Quality of Specifications,* ASCE Journal of the Construction Division, Vol 104, No. C02 (ASCE, June 1978), pp 153-156.

6. The listing of inspection items in the CQC provisions of the specifications is redundant. QC should be practiced on all requirements of the technical provisions, and QA should not be limited only to items listed in the CQC provisions.

Summary of Survey Results

This field survey indicated that there is no single reason for poor performance of BUR. Design errors, unclear and ambiguous specifications, poor workmanship during application, and inadequate QC and QA inspection all significantly influence BUR performance.

Full-time inspection by qualified individuals can provide improved roof application. However, inspection, no matter who performs it (i.e., QC, QA, third-party contractor), is not the sole solution to improving the quality of roofing.

4 RECOMMENDATIONS

The following recommendations to improve quality control and quality assurance of BUR are based on evaluation of the state of the art of quality control and the findings of a field survey of the Corps' current QC/QA practice. Although some respondents interviewed recommended broad changes to QC, the recommendations presented here address the more limited objective of this study, i.e., to suggest ways of improving the effectiveness of the QC/QA program in its application to built-up roof construction. The order of presentation does not indicate any priority of need.

1. Improve coordination of plans and specifications, consistency within specifications, and details in plans. Guide specifications should be kept consistent with the state of the art and should be used as a guide, not as a master for all specifications.

2. Enforce contract specifications consistently. When compliance with specific items will be waived, the contract should be amended.

3. Require submittal of proposed construction details and materials by contractor if the phrase "as recommended by the manufacturer" is used.

4. Require designers to provide details of insulation installation at drains, intersecting walls, penetrations, and other areas where thickness may vary and interface problems may occur.

5. Require temperature chart recorders on all asphalt kettles. Include evidence of recent calibration. This provides an inexpensive permanent record for monitoring bitumen temperatures. Require monitoring of asphalt temperature at point of application on the roof using portable thermometer at appropriate intervals during asphalt application.

6. Require preconstruction meetings specifically devoted to roof construction to insure that project requirements and responsibilities are understood by all parties.

7. Provide full-time quality control inspection on BUR construction.

8. Specify the contractor's quality control responsibility and authority in the contract. One method of doing this would be to modify the technical specifications to define requirements relating specifically to roof construction and modify special provisions to include requirements that are also applicable to other types of construction.

9. Use quality assurance to check the performance of QC. Techniques for performing and reporting* of quality control should be developed for Corps-wide use. A checklist should be developed for acceptance of QC plans.

10. Revise EP 415-1-262, Chapter 207, to provide QA inspection guidance.

11. Train QA personnel not only in roofing technology but also in the objectives and performance of QA.

*Appendix C provides examples of some forms currently used for daily reports. The first form is preferable since it is designed specifically for roofing.

APPENDIX A*
QUALITY CONTROL/ QUALITY ASSURANCE (QC/QA) OBSERVATIONS AT SELECTED SITES (SPECIAL PROCEDURES USED OR UNUSUAL CONDITIONS OBSERVED)

The unusual QC/QA programs observed at two of the seven sites surveyed are described in the following discussion. Personnel at the Resident Engineer's Office at Site 1 indicated that the QC on the hangar construction was very effective. Although the QC performer had no previous experience in roofing, he had developed a good basic knowledge in this area and was attempting to provide the Corps with a good built-up roof system (BURS). Resident Engineer's Office personnel stated that they have very few problems with roofs and generally receive good quality roofs in their construction programs. Both Resident Engineer's Office personnel and the QC indicated that the flashing details in the contract specifications should be improved.

During the on-roof survey, two minor deficiencies were noted:

1. The spacing of nails in the backnailing of the No. 15 felts was not as specified in Table III, Section 7c, of the contract specification. As required, the nails were in two rows approximately 2 in. (51 mm) and 6 in. (153 mm), respectively, from the upper edge; but within each row they were on 24-in. (610 mm) centers rather than on 12-in. (305 mm) centers as specified.

2. The insulation and felts appeared to be properly stored and covered with plastic. However, the plastic, although covering well on the top, had blown off, exposing the sides of some of the insulation and felts to the weather. These materials may have been uncovered during a rain and wind storm the previous night. In spite of this apparent exposure, neither the insulation nor felts appeared to be wet, but exact moisture content was not determined.

About one-fourth of the roof membrane was completed, including mineral cap sheet; one-half was completed except for mineral cap sheet; and the remaining one-fourth had yet to be started. Flashings had not yet been installed. The construction and inspection generally appeared to be of good quality.

Roof construction at Site 2, although being done under the QC/QA program, was not at all typical. The Office of the Chief of Engineers (OCE) had directed the responsible District of the Army Corps of Engineers to retain an Architect-Engineer (A-E) firm to review the roofing portion of the contract specifications and to furnish a full-time on-site inspector experienced in roof construction. This job is part of an OCE program where the contract specifications for a few selected roofs are reviewed for adequacy, and full-time inspection is provided by an A-E. This program is being conducted as an experiment to determine if the combination of a good contract specification and full-time inspection will result in longer-lasting BURS.

The QC performer had little knowledge of roof construction. As a result, he had delegated most of his roofing responsibilities to the roofing subcontractor's superintendent. As required by the contract, a daily report, including roofing, was prepared by the QC. The QC made his required once-daily inspection of roofing construction late in the afternoon; the inspection was brief, as were any comments on roofing in his daily QC report. Under these conditions, the only meaningful inspections were performed by on-site Corps QA personnel.

Because the full-time A-E representative was not yet available, Corps QA personnel performed the inspections during construction of the roof on the north wing, although their many other duties precluded visits more than once or twice a day. As the north wing was being completed, the A-E firm furnished a full-time inspector as part of the aforementioned program. Since QA personnel were unable to give adequate time to roof inspection and since the A-E representative was on-site full-time, OCE was requested to designate the A-E representative as a QA inspector. The request was approved by OCE, providing full-time QA inspection of construction of all roofs except the north wing.

In the on-roof survey, the only deficiency noted during application of the membrane was in the brooming of the felts. The roofer was brooming only one side of the felt rather than the full width. This was brought to the attention of the QA, who corrected the brooming procedure. However, by the time the roof was completed the mechanic was again brooming only one side. This points out the difficulty in trying to get

*This Appendix and Annexes 1 and 2 are excerpts from a report done for this study by R. L. Alumbaugh and J. R. Keeton of the Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, CA.

workmen to change long-standing habits. In spite of that problem, this appeared to be a good roofing crew attempting to follow the contract specification. It appeared that the BUR was being applied in accordance with the specification. However, there were three areas in which the Resident Engineer's Office personnel, as well as the roofing subcontractor, disagreed with the specification. These differences are discussed below. In addition to these comments on the specification, personnel interviewed stated that roof specifications should be tailored to local geographical areas.

1. The specification requires that the gravel surfacing be applied the same day the roof is constructed. It is felt that such a procedure is more detrimental than beneficial. Because of the high ambient temperature at Site 2, the interply bitumen cools rather slowly. As a result, when gravel is applied the same day the membrane is constructed, it is quite possible that roof mechanics walking or pulling gravel buggies across the newly graveled surface may cause the gravel to puncture the membrane. It is believed that a better procedure would be to glaze coat the membrane and then flood coat and gravel later.

2. The specification required loose gravel to be removed from the surface. This has resulted in numerous bare areas where the gravel has settled into the heat-softened flood coat. Leaving the excess gravel in place until later in the construction process should minimize the number of bare areas. Where the flood coat has been exposed (by loss of gravel) the bitumen may alligator from exposure to sunlight.

3. No vapor barrier was specified over the concrete roof decks. Not only would such a vapor barrier retard permeation of moisture from the concrete into the insulation, it also would have provided adequate waterproofing of the roof deck to enable construction work to continue below deck and allowed the roofing subcontractor to follow better construction practices.

One additional problem with the construction at Site 2 not covered by the contract specification was the size of the urethane insulation board. The roofing subcontractor had chosen to use 4- x 8-ft (1.22- x 2.44-m) boards. Because of their size and a tendency to warp slightly when subjected to the hot asphalt, the insulation boards were not properly bonded to the deck. To overcome this, a change order was initiated to increase the amount of bitumen from 20 lb/sq ft (98 kg/m^2) to 50 lb/sq ft (244 kg/m^2). According to the QA, this had eliminated the bonding problem. However, it was noted during the on-roof survey that one board was not firmly bonded, but was protruding above the surrounding boards at one corner. This was pointed out to the QA, and the subcontractor reinforced this area with an additional layer of felt prior to application of the three-ply membrane. It is believed that a more effective way to handle the bonding problem would be to limit the size of the urethane insulation board to 3 x 4 ft (.915 x 1.22 m), a size which can be bonded more easily with 20 to 25 lb/sq ft (98 to 144 kg/m^2) of bitumen.

In addition to the information obtained during the on-roof surveys, some rather interesting comments were obtained during discussions with the Resident Engineer's Office and QC personnel. The Resident Engineer at Site 1 expressed the opinion that the QC/QA program is an effective inspection system that should provide the Army Corps of Engineers with good roofing systems. The project engineer in charge of QA believes that the effectiveness of the CQC program depends on the contractor, but generally it is a dismal failure. Of the six contracts over which his QA team currently has cognizance, only one has an effective CQC program. In fact he indicated that this particular CQC program was the most effective he had ever seen. He stated that the QC performer frequently does not understand his function or what he is supposed to do. As a result, he is frequently an expediter for the contractor. Ineffective QC places an especially heavy burden on the QA personnel who attempt to obtain a good roof job. The QA inspector believes much better roofs would be obtained by conducting the inspection in-house. The QC performer on this particular contract believes that QC practice is adequate.

The relationship between the QC performer and the Resident Engineer's Office at Site 2 was quite different from that at Site 1. There had been numerous disagreements at Site 2 over contract items which were difficult to resolve. The first of these differences occurred over the CQC plan, which had originally been rejected by the Resident Engineer's Office. The CQC plan that was finally adopted was very poor and did not really specify duties relating to roof inspection. The Resident Engineer and his staff thought that the present QC system at Site 2 was ineffective. In more general terms, their opinion was that the CQC system is only as effec-

tive as the integrity of the prime contractor. If he intends to do a good job, CQC will work effectively. If not, a heavy burden is placed on QA personnel to assure good construction. Because full-time roof inspection is being provided by the A-E at Site 2, the ineffectiveness of the CQC program is not a factor in obtaining good roof construction.

The Resident Engineer's Office personnel at Site 2 had several alternatives which they recommended for an effective CQC program. These alternatives are listed below in their order of preference.

1. The most effective quality control program would be one carried out in-house using Government inspectors. Such an in-house program would eliminate many of the current problems with the CQC program.

2. If Government employees are not available, the next most effective quality control program would be to have the inspection done by an independent firm retained by and responsible to the Government. This should eliminate the conflict of interest inherent in the current CQC program.

3. The current CQC program, if used, should be modified so that the CQC program is spelled out in detail in the contract rather than left entirely up to the contractor. It was felt that many of the problems with the CQC program could be eliminated if the Corps would provide more detailed information on the function of the QC in the CQC program, e.g., the duties of the QC, what qualifications the QC should have, and what percentage of the QC's time should be spent on the roof.

The QC at Site 2 had much the same viewpoint on the QC program as the Resident Engineer's Office. He felt that the QC and QA did not really understand each other's functions and that these functions should be defined in the contract. The QC believed that the CQC function as written in the contract will never work beyond the material submittal and initial inspection stages. His reasoning appears to be that, without a better definition of function, there will always be conflict between the QC and QA, and this conflict will not diminish as long as the QC is employed by the contractor. If the Corps cannot perform the QC function, he would prefer to see an independent firm retained by the Government performing the inspections.

ANNEX 1: SPECIFIC RESPONSES TO QUESTIONS–SITE 1

1. RESIDENT ENGINEER STAFF

a. Contract and Roof Details

(1) Experience of Contractor (Roofing)

Roof Sub: Experienced roofing contractor with fairly good reputation.

(2) QC Performer–an employee of the General Contractor.

(3) Roof System Composition

Fluted metal deck (9/16 in./ft [47 mm/m] slope); 2 in. (50.8 mm) fiber insulation (mechanically fastened); three No. 15 glass fiber felts (hot-mopped and back-nailed); No. 90 mineral cap sheet (approximately 10-ft [3.05-m] lengths).

(4) Adequacy of Plans and Specifications

Adequacy is first checked by Technical Review Section at District Headquarters; Resident Office checks them briefly; this is called a Constructibility Review (mainly examines utility connections, etc). The plans and specs for the current job were generally considered adequate, but flashing details should be more specific; sometimes roof slopes are not considered and reglet may disappear beneath the membrane. This leaves too many decisions to be made by the roofer on flashing details. It was also observed that much irrelevant material is retained in the specification; for example, there are sections dealing with what to do on concrete or wood roof decks when the deck on the job is actually steel.

b. QC and QA Procedures

QC is accomplished by personnel of the prime contractor; QA is accomplished by personnel of the Corps of Engineers Resident Engineer's Office.

(1) Format and Content of Contractor QC Plan

(a) The specification requires the prime contractor to prepare the QC plan. The Resident Engineer's

Office then approves the plan in writing and sets the responsibility of the prime contractor to expedite the QC plan. The QC plan says that a certain individual, an employee of the prime contractor, is responsible for assuring by constant inspection that all aspects of the contract specifications are complied with during construction.

(b) Format: Introduction, Index, Company Direction, Job Site Direction, Date Control, Material Control, Action Identification, Specific Specification Checklists.

(2) Preconstruction Conference

(a) A preconstruction conference is held to discuss the QC program as mentioned above. The primary concern of this conference is to agree on how the QC program is to be implemented.

(b) Another preconstruction conference is held prior to initiation of each phase of the construction. This second meeting is to reach general accord on the contract requirements for the roofing system.

(3) Initial, Interim, and Final Job Inspections

The Resident Engineer's Office tries to assure that the QC conducts these inspections in sufficient depth.

(4) Material Submittals

The Resident Engineer's Office has specific forms for these submittals; they are submitted to the Resident Engineer's Office by the prime contractor (the QC), and not accepted from any subcontractors.

(5) Daily QC/QA Report or Log Books

A daily report from the QC is required by the contract and is given to the QA representative. Daily QA reports are also required. The QA reports do not duplicate the QC reports; they either supplement the QC report, agree with it, or disagree with it.

(6) Equipment and Tests Required

Except for measurement of asphalt temperature, no tests are required directly by the QC; required tests are done by private firms (outside) under contract to the prime contractor, who then submits the results to the Resident Engineer's Office.

(7) Inspector Checklists Used

No checklists are required by the Resident Engineer's Office, and none are used by the QC.

c. Resident Engineer Responsibilities

(1) Interaction with QC/QA Personnel

The Resident Engineer prefers to work through the QC in dealings with the roofing subcontractor; he prefers this arrangement because it puts more responsibility on the prime contractor to attain quality in construction. QA personnel, who are part of the Resident Engineer's staff, usually deal with the QC but, if necessary, can deal directly with the contractor. At times, the Resident Engineer, working through the QA, has asked the prime contractor to replace the QC because of incompetence. At Site 1, there are several QA teams, each consisting of a Project Engineer (GS-11) and two QAs (inspectors, GS-7). The team responsible for this job is currently working on six jobs, which means that they are, on the average, spending no more than one-third of their time on roofing.

(2) Enforcement Functions in QC/QA

The Resident Engineer has told his QA personnel not to "stand over" the QC; when the QC is on the roof, the QA does not go up. If the QA and QC cannot come to an understanding, a meeting is held in the Resident Engineer's Office to resolve the problem. If necessary, the Resident Engineer's Office will issue a letter of direction to the prime contractor, stating what the specifications require, or perhaps issue a change-order.

(3) Pressure from Superiors for Job Deadlines

There is always, at the least, subtle pressure to complete all construction jobs on time.

(4) Support from Contracting Officer in Contract Violations.

The Contracting Officer has always supported the Resident Engineer in disputes with contractors. However, before a dispute is taken this far, the

Resident Engineer's Office makes sure that its position is correct.

(5) Philosophy and Procedure for Job Stop-Orders

The Resident Engineer prefers to handle any difficulties verbally if possible. It has seldom been necessary to issue a stop-order in writing; occasionally, however, it has been necessary to withhold payment until an order has been complied with.

(6) Personnel Available for QA

The Resident Engineer believes he has adequate personnel for QA, although he would prefer that they be better trained and would prefer higher grade levels for them.

(7) Level of Training for QA Personnel

Training courses (and training funds) are available, but there is not enough time to attend enough of them. Since inspectors may be working with as many as 10 different disciplines, they cannot be expected to have experience or expertise in all of them.

(8) Funds Available for QA

Adequate funds are available, including funds for training.

d. Roofing Problems

(1) What are significant problems in roof construction?

(a) Flashing and counter flashing.

(b) Government requirements are different from standard practice in industry.

(c) Weather conditions and delays sometimes cause contractors to work when they should not.

(2) What are persistent contractor violations?

Base and counterflashing installation (poor quality labor).

(3) Recommend QC/QA procedures to rectify problems and violations.

The Resident Engineer believes that present QC/QA procedures are adequate to obtain good roofs.

2. QA PERSONNEL

The man interviewed was a GS-11, Project Engineer, in charge of two inspectors. The inspector on the job was at a training school.

a. Level of time available or devoted to QA

Six construction jobs must be handled by two inspectors; therefore, an inspector devotes at most 25 to 30 percent of his time to roofing.

b. Level of training in roofing and in QA practice

The inspectors have some experience in general construction but practically none in roofing.

c. Availability of roof plans and specifications

Plans and specifications are always available.

d. Enforcement Functions

(1) Responsibility of QA Personnel

The QA has very little actual responsibility; he is merely an observer for the Resident Engineer.

(2) Support from Superiors

The QA has very good support from superiors in all QA actions. He has now been assigned a heavier workload (a new squadron moved in), but was given no additional inspectors to perform the extra work.

(3) Interaction with Contractor and QC Staff

The QA interacts with these personnel every day. In addition, the QC must submit daily reports to the QA.

e. QA Practice

(1) Are checklists used?

The only checklists required relate to safety. The QA feels that checklists are not meaningful and feels that they often become a crutch.

(2) Are tests taken?

Except for measurement of asphalt temperature, the QA conducts no tests, but can if he feels it is necessary.

(3) Are test methods understood?

Yes, when applicable.

(4) Is test equipment available?

Yes.

(5) Are present tests adequate?

Yes.

f. Roofing Problems

(1) What are significant problems in roof construction?

There have been very few problems at Site 1 for more than 3 years, with the exception of some poor flashing design.

(2) What are persistent contractor violations?

None have been noted. The QA tries to avoid contractor violations by taking proper steps before roof construction starts.

(3) Recommended QC/QA procedures to rectify problems and violations.

Not applicable.

(4) General comments by QA on the QC/QA system.

The effectiveness of the QC procedures varies with the contractor; a large well-established contractor can have an effective QC program. Of the six jobs under his cognizance now, only one contractor has an effective QC program. When the QC is not functioning effectively, a heavier burden is placed on QA personnel. He thinks that the QC program is a failure, probably because the contractors who are responsible for the CQC feel that they cannot afford to do the job efficiently. The QA believes that inspectors should be college graduates. The QC often becomes an expediter for the contractor, and some QC personnel do not understand their function.

3. QC PERSONNEL

a. Level of time available or devoted to QC

Twenty percent to roofing (50 percent on roof, 50 percent paperwork)

b. Level of training in roofing and in QC practice

This is the QC's first experience in roofing and also his first job as a QC.

c. Availability of and familiarity with plans and specifications

Readily available; the QC is familiar with plans and specifications.

d. Enforcement functions

(1) Responsibility of QC personnel

QC personnel must insure that what has been specified is constructed. The QC has the authority to correct wrong actions. Together, he and the Engineering Department of the contractor (general) prepared the QC plan.

(2) Immediate supervisor in contractor's (general) organization

The project manager.

(3) Interaction with QA staff

The QC has contact with QA staff every day, and their relationship is good.

e. QC Practice

(1) Are checklists used?

No.

(2) What materials and reports are submitted? To whom?

Daily reports are submitted to the Resident Engineer (through QA personnel).

(3) What tests are required?

The QC checks the asphalt temperature on the ground each morning and the temperature on the roof periodically.

(4) Are test methods defined and equipment available?

N/A.

(5) Is the present QC practice adequate?

Yes.

f. Roofing Problems

(1) What are the most significant problems in roof construction?

The QC has never seen roof construction before and doesn't know what the significant problems are. At the beginning of the job, he asked the civil engineering people what he should look for.

(2) What specification requirements are most difficult to comply with?

The specification calls for nailing the felts to the insulation (fiberglass) with 20-lb (9.1-kg) holddown; this is difficult to obtain with fiberglass insulation. Also, in base flashing requirements, only the last sentence of the long paragraph applies.

(3) What difficulties exist in interaction with QA function?

Whatever difficulties develop (and there are few) are handled orally.

(4) Recommend QC procedures to minimize roof failures.

Since the QC had no previous experience in roofing and there were no failures on this project, he could not answer this question.

4. FIELD OBSERVATIONS

a. Are inspectors (QC and/or QA) present at the start and close of a day's work?

The QC is usually there early in the morning but not necessarily at the start; the same is true for late afternoon. The workmen usually stop roofing about 2:00 p.m. and begin on water cutoffs (workmen leave at 3:00 to 3:30 p.m.).

b. Is the temperature of the bitumen monitored? How? By Whom?

Yes, by thermometer (QC or QA); in addition, the asphalt tank truck on the ground has a temperature indicator.

c. Are materials stored properly? Who inspects this?

Yes, materials are wrapped with plastic; the QC inspects this.

d. Is the deck acceptable for roof construction? Who determines? How?

The QC determines that in the beginning, and continues to monitor it.

e. Document QC practice and records observed?

Yes. QC records observed.

f. Document QA practice and records observed?

Yes. QA records observed.

g. What contract violations were observed? What was done about them?

(1) The spacing of nails in the backnailing of the felts was not as specified in Table III of Section 7c of the contract specification. The two rows of nails were approximately 2 in. (50.8 mm) and 6 in. (152 mm) from the upper edge, but the on-center nail distance was 24 in. (61 cm) rather 12 in. (30.5 cm).

(2) The plastic wrapping had blown off the sides of some of the insulation and felts which had been stored on the ground. This probably occurred during the previous night during a storm. Materials did not appear to be wet.

ANNEX 2: SPECIFIC RESPONSES TO QUESTIONS–SITE 2

1. AREA OR RESIDENT ENGINEER STAFF

a. Contract and Roof Details

(1) *Experience of Contractor*

General: Large contractor, experienced in large construction projects.

Roof Sub: Relatively large, experienced roofing contractor.

(2) QC Performer–an employee of the General Contractor. The general contractor shifts the QC responsibilities to the subcontractors. The superintendent for the roofing subcontractor handles the quality control for the subcontractor. However, QC reports are submitted by the QC performer.

(3) Roof System Composition. The medical center additions were quite complex, having several roofs. The major roofs and their status are listed below.

North Wing: Fluted metal deck, structural lightweight concrete for slope, 2.65 in. (67.3 mm) of urethane insulation board, one ply of No. 43 base sheet, three plies of No. 15 felt, and gravel surfacing.

South Wing: Structural concrete deck topped with lightweight insulating concrete to slope to drain, asphalt primer, 2.65 in. (67.3 mm) of urethane insulation board, four plies of No. 15 felts, and gravel surfacing. One section of this wing was virtually complete except for a 10-ft (3.05-m)-wide area around the perimeter. This had not been completed, because other subcontractors had not completed their work along the edge of the roof.

Porch: One story extension on the west side. Structural concrete deck topped with lightweight insulating concrete to slope to drain, asphalt-primed, 2.65 in. (67.3 mm) of urethane insulation board, four No. 15 felts, and gravel surfacing. Roof was under construction during visit.

(4) Adequacy of Plans and Specs

Three requirements of the roofing spec were considered questionable by the Area and Resident Engineers' Offices.

(a) Application of the gravel surfacing on the same day that roof was constructed. Because of high ambient temperatures in the area, workmen walking on newly constructed and graveled BUR might puncture the membrane. The staff believes a glaze coat should be adequate initially, with flood coat and gravel added at the end of the week.

(b) Lack of vapor barrier (or a "drysheet"). Application of a vapor barrier over the concrete roof deck would have provided adequate waterproofing of the deck to enable the prime contractor to proceed with below-deck construction without forcing the roofing subcontractor to prepare a piecemeal BUR system.

(c) Vacuuming of loose gravel surfacing. Vacuuming of loose gravel surfacing too soon has resulted in numerous bare areas caused by settling of gravel into the heat-softened flood coat. Leaving excess gravel until completion of construction should result in lower surface temperatures and less softening of the flood coat.

b. QC and QA Procedures

(1) Format and content of contractor QC plan

(a) The QC plan is very poor

(b) The amount of time required for the QC in roofing is not stipulated.

(2) *Preconstruction conference*

(a) There was a preconstruction conference between the Resident Engineer's Office and the prime contractor prior to contract initiation.

(b) There was a preconstruction conference between the Resident Engineer's Office, the prime contractor, and the roofing subcontractor prior to roof construction.

(3) Initial, Interim, and Final Job Inspections

(a) Initial inspection–QC, QA, and the roofing subcontractor QC.

(b) Interim inspection–QC, QA, and the roofing subcontractor QC.

(c) Final inspection–QC, QA, roofing subcontractor QC, and the user.

(d) In addition, OCE directed the District to retain an A-E firm to provide full-time inspection during roof construction. The Resident Engineer's Office decided to have the A-E representative perform most of their inspection functions.

(4) Material Submittals

(a) Handled by the prime contractor's QC and submitted to the QA for approval.

(5) Daily QC/QA Reports

(a) Daily reports submitted by the QC and QA (A-E representative).

(6) Equipment and Tests Required

(a) Equipment: thermometer

(b) Tests: type of asphalt, moisture content of gravel surfacing, insulation and felts, and membrane sample cutouts.

(7) Inspector Checklists: none

c. Area/Resident Engineer Responsibilities

(1) Interaction with QC/QA Personnel

(a) He tries to provide two training classes per week for QA personnel on a variety of subjects. Classes on roofing are held infrequently.

(b) Attempts to stimulate the QC to do a more effective job.

(2) Enforcement Functions in QC/QA

The job can be shut down when required, such as for substandard work or materials.

(3) Pressure from Superiors for Job Deadlines

There are no pressures on this job. The only requirements are that the job be completed within contract time.

(4) Support from Contracting Officer in Contract Violations

Sometimes they have support from the Contracting Officer, and other times they do not. They do not always agree on what constitutes support.

(5) Philosophy and Procedure for Job Stop-Orders

The Project Engineer issues an oral stop-order. If this is not sufficient, the Resident Engineer issues a written stop-order.

(6) Personnel Available for QA

Since the A-E representative is available for full-time roof inspection, the staff considers this to be adequate. QA personnel are available for roofing on the job, when required.

(7) Level of Training for QA Personnel

Only one QA per year from the Area Office attends a 1-week roofing school.

(8) Runds Available for QA

Normally there is enough funding for QA only if the QC does an effective job.

d. Roofing Problems

(1) What are the most significant problems in roof construction?

Flashing at penetrations and edges. There are normally no problems with membranes in the center of the roof unless it is built over lightweight insulating concrete.

(2) What are the most persistent contractor violations?

No persistent violations.

(3) Recommended QC/QA procedures to rectify problems and violations.

(a) The QC program should be spelled out in detail in the contract rather than leaving it up to the contractor. They feel the Corps should tell the contractor what the QC should do, what qualifications the QC should have, how much time the QC should spend on the roof, etc.

(b) When the Corps conducted its QC/QA in-house, it was not getting 100 percent roof inspection, but still obtained good roofs. The Corps' recommendations are, in order of preference; (1) have all QC/QA in-house conducted by Government personnel; (2) have all inspections done by an independent inspection agency paid by the Government; and (3) spell out the QC plan specifically in the contract specification as outlined above.

1. QA PERSONNEL

a. Level of time available or devoted to QA on this particular job.

The QA (the A-E representative) was on the roof 100 percent of the time.

b. Level of training in roofing and in QA practice.

The Resident Engineer's office has very little experience in roofing.

c. Availability of roof plans and specs.

Readily available.

d. Enforcement Functions

(1) Responsibility of QA Personnel

To insure that the roof is built in accordance with the specification.

(2) Support from Superiors

Good.

(3) Interaction with Contractor and QC Staff

To discuss discrepancies, QA first contacts roofing QC orally. If oral contact is insufficient, a written notice is provided. If contract modifications are required, a change-order is issued.

e. QA Practice

(1) Are Checklists Used?

No.

(2) Are Tests Taken?

Yes, to determine the temperature of the asphalt, both in the kettle and on the roof, on a routine basis. Had cut-outs taken to determine bonding of insulation to roof deck. Private laboratory determined moisture content of felts, insulation and gravel, and type of asphalt.

(3) Are Test Methods Understood?

Yes.

(4) Is Test Equipment Available?

Yes. Thermometers are available.

(5) Are Present Tests Adequate?

Yes.

f. Roofing Problems

(1) What are the most significant problems in roof construction?

No significant problems.

(2) What are the most persistent contractor violations?

None.

(3) Recommended QC/QA procedures to rectify problems and violations.

Contract should specify QC duties and time to be spent on the roof. He should be on the roof at start-up and at the close of the day. The QC should monitor asphalt temperatures.

3. QC PERSONNEL

a. Level of time available or devoted to QC.

Bare minimum by prime QC–probably 10 to 30 minutes daily. He inspects once a day generally at the end of the day.

b. Level of training in roofing and in QC practice

The QC has been a contract superintendent, so he has therefore had QC experience, but has had very little roof experience or training.

c. Availability and familiarity with plans and specs?

Yes.

d. Enforcement functions

(1) Responsibility of QC personnel. He sees his responsibilities as:

(a) Checking submittals for compliance with contract.

(b) Checking materials on the job to make sure they are satisfactory.

(c) Making sure subcontractors understand specification requirements and that any required testing is carried out.

(d) Making sure decks are ready for roof system (this is generally done in conjunction with the roof contractor superintendent and the QA).

(2) Immediate Supervisor

Contract manager.

(3) Interaction with QA staff

Problems are discussed with the QA in the field. If the problem cannot be settled, it is discussed with the Corps Project Engineer and then documented in his daily report.

e. QC Practice

(1) Are checklists used?

No.

(2) What material reports are submitted and to whom?

(a) Daily reports are submitted by the QC to the Resident Engineer's Office.

(b) Material submittals are made by subcontractors to the QC, and he submits these to the Resident Engineer's office.

(3) What tests are required?

The QC said that these are spelled out in the contract in Technical Provision 1-b.

(4) Are test methods defined and equipment available?

No. Test methods are not always defined, and the frequency of testing is usually not defined.

(5) Is the present QC practice adequate?

The QC says this question is hard to answer on this job because of the full-time inspection by the A-E representative.

f. Roofing Problems

(1) What are the most significant problems in roof construction?

(a) Corps specifications are not tailored to the area or to the materials available in the area; e.g., the roofing gravel specified was not available in that area.

(2) What specification requirements are most difficult to comply with?

(a) Must complete entire BUR (including graveling) in a given area in one day.

(b) Need better definition of some portions of specification, e.g., specification says roofing cannot be started until an area is ready (i.e., what does "ready" mean?).

(3) What difficulties exist in interaction with QA function?

QC and QA do not understand what the other's functions are. Need better definition of these functions in the contract specification.

(4) Recommended QC procedures to minimize roof failures

He believes that CQC as written in the contract will never work beyond the submittal portion and initial inspection. Once a contractor starts work, this QC cannot see the value of having both the QC and QA doing the same function (inspection). This QC doesn't think conflict will ever disappear as long as the contractor hires the QC; he would prefer to see an independent outside agency doing the QC, if the Corps cannot do all of it.

4. FIELD OBSERVATIONS

a. Are inspectors (QC and/or QA) present at the start and close of a day's work?

Yes. The A-E representative is present 100 percent of the time that the roofing work is being done. QC and Corps QA are present occasionally but not necessarily at the start or close of work.

b. Is the temperature of the bitumen monitored? How? By Whom?

Yes. By subcontractor personnel and the A-E representative. Uses pocket thermometer. Temperature of asphalt at pot is 450°F. Application temperature is about 430°F.

c. Are materials stored properly? Who inspects this?

Yes. These are inspected by the A-E representative.

d. Is the deck acceptable for roof application? Who determined this? How?

Yes. QC, QA, and Q-E representative. Acceptability is determined by observation.

e. Document QC practice and records observed.

"Real" QC is done by the roofing subcontractor foreman, who keeps no records. The QC reports from the prime contractor were not made available by the Resident Engineer's office.

f. Document QA practice and records observed.

QA is carried out by the A-E representative who was on the roof 100 percent of the time.

g. What contractor violations were observed? What was done about them?

The only violation noted was improper brooming; this was corrected.

APPENDIX B: QC/QA OBSERVATIONS AT SELECTED SITES (NORMAL PROCEDURES USED)

This appendix describes findings at two of the seven sites visited. Normal QC/QA practices were being followed at these two sites; i.e., the General Contractor performed the QC, and the Resident Engineer's staff performed the QA. Annexes 1 and 2 provide specific responses to questions that CERL asked personnel at Sites 3 and 4, respectively.

The roof had already been completed when Site 3 was visited, but a visual inspection disclosed a few deficiencies. Aggregate had not been embedded uniformly in the flood coat, and flashing for one vent had not been thoroughly flooded with asphalt after completion.

The roof for Site 3 was simple in shape and design, having a ridge down the center, with both sides sloping to the edges and a hip at each end. The roof deck was steel on bar joists. The contractor complained that having a hipped roof necessitated bending the steel roof deck along the ridges, and that the resultant shape was not as designed.

The roof at Site 4 consisted of formboard on steel structure, with a gypsum deck above; the formboard was covered with a vapor barrier, insulation, and four-ply built-up roof, with a final topping of a fibrous, aluminum-pigmented roof coating instead of a flood coat and aggregate. This roof also had one longitudinal ridge sloping toward both sides, but there were no hips at the ends. Both the contractors and the Resident Engineer disagreed with certain provisions of the contract specifications. They felt that allowing the Contractor some choice in certain operations would provide a better product. These differences are discussed below.

1. The specification at Site 3 requires that the steel deck be welded to the supporting structure. Nailing or clipping the steel deck in place would eliminate the inevitable burn-throughs from welding, and avoid the need for subsequent repair and touch-up painting.

2. The contract specifications are very restrictive in their temperature requirements for molten asphalt. Manufacturers have begun to publish "equiviscous temperature" (EVT) information, which is the temperature to which any given batch of asphalt must be heated to provide the optimum viscosity for laying felts. Since asphalt manufacture is not an exacting process, this temperature varies from one manufacturer to another, and even varies among products from a single manufacturer, depending on the prime material being distilled at the refinery. Allowing the contractors to follow the asphalt manufacturer's EVT recommendation and close temperature monitoring at the bucket on the roof would insure that asphalt of the proper viscosity was being used for felt application.

3. As stated in Appendix A, the specification at Site 3 requires that gravel surfacing be applied the same day that the roof is constructed. If this procedure is followed, it becomes necessary to walk on the newly laid roof to apply the flood coat and spread the aggregate. Much of the roof is still hot and soft, and the walking causes tears in the surface. In addition, the specification clearly states, "do not walk on mopped surfaces while the bitumen is sticky." A better procedure would be to apply a glaze coat first, and then flood and spread the aggregate the next day.

4. The contract for Site 4 requires all work to be completed the same day; however, use of the fibrous aluminized coating on this job makes it impractical to install the sheet metal simultaneously with the roofing, because the surface coating takes a long time to cure. If no other work is done, 2 days are sufficient, but along the walls where sheet metal work is to be done, the surface coating must cure for a week before it can be walked on.

ANNEX 1: SPECIFIC RESPONSES TO QUESTIONS—SITE 3

1. RESIDENT ENGINEER STAFF

a. Concerning contract and roof details:

(1) What is the experience of the roofing contractor?

Roof Subcontractor: Had never previously installed a military roof, and at first complained about following the specifications, but soon realized he had no choice but to perform as required.

(2) Who actually performs the CQC?

The construction superintendent of the General Contractor, who has been with his company for

more than 26 years. He has installed several roofs for the Government.

(3) What is the construction of the roof system?

Fluted metal deck (1/4 in./ft [21 mm/m] slope). Organic fiber insulation board, two layers, each 1/2 in. (38.1 mm) thick; four No. 15 organic felts, hot mopped in place; 60 lb/sq ft (292 kg/m^2) flood coat with aggregate surface.

(4) How adequate are the plans and specifications?

Drawings and specifications are clear and easy to follow, but are not always correct. This led to differences of opinion between the contractor and the Resident Engineer. For example, there is a serious difference between the plastic base flashing in the specifications and that on the drawings. The specifications specify two-ply base flashing, while the drawings specify five-ply base flashing. The contractor requested instructions, and was told to install two-ply flashing to comply with the specifications.

(b) Concerning QC and QA procedures:

QC was performed by the Field Superintendent of the General Contractor; QA was performed by the Resident Engineer, who employed no inspectors at the time.

(1) What were his comments concerning the format and content of contractor QC plan?

This was considered adequate because of the relatively small size of the job.

(2) Was there a preconstruction conference? What was discussed?

A preconstruction conference was held to discuss the CQC plan, the safety plan, and details of submittals for approval. The primary concern of this conference was to agree on how these plans are to be implemented.

(3) Who conducts the initial, interim, and final job inspections?

These are conducted by the QC, the QA, and subcontractor together.

(4) How are materials submitted for approval?

These are submitted by the QC to the QA on standard forms specified in the contract.

(5) Are daily QC/QA reports or log books required?

A daily report from the QC is required by the contract. This is given to the QA (in this case, the Resident Engineer).

(6) What equipment and tests are required?

No tests are specifically required. Asphalt maximum temperature is specified only for use with asphalt-saturated felts, and a hand-held thermometer is used for verification.

(7) Are checklists used by the QC inspector?

No checklists are required by the Resident Engineer's Office, and none are used by the QC.

c. Concerning Resident Engineer responsibilities:

(1) What interaction does the Resident Engineer have with QC personnel?

Since the Resident Engineer performs the QA, he is in daily contact with the QC. This avoids loss of time and details through the interaction of a third person.

(2) What are the Resident Engineer's enforcement functions in QC/QA?

The Resident Engineer has a letter of authorization as Contracting Officer's Representative (COR). This letter directs him to issue "instructions to the contractor affecting the performance of contractor work," which he feels gives him complete authority to act within the limits of the contract specifications. He cannot authorize changes; these must be issued by the Contracting Officer.

(3) Does the Resident Engineer experience any pressure from superiors for meeting job deadlines?

Since the job was completed ahead of schedule, the Resident Engineer experienced no pressure.

(4) Does the Resident Engineer receive adequate support from the Contracting Officer in the decision of contract violations?

No disagreements ever had to go to the Contracting Officer for decision, but the Resident Engineer was sure that he would receive proper support.

(5) What is the Resident Engineer's philosophy and procedure for issuing job stop-orders?

Although he would not hesitate to shut down the job if he felt it was necessary, this action was never required.

(6) What personnel are available for QA?

The Resident Engineer has a staff of three people to accomplish seven jobs. He is the only one who has taken the General Inspectors Training Course, and therefore performs the QA function himself.

(7) What funds are available for QA?

No extra funds are available. QA must be performed by regular staff.

d. What problems have occurred during this particular construction?

The roofing subcontractor had never installed a roof to military specifications before, and at first complained about having to follow them. Once he realized compliance was necessary, he followed the specifications and produced good quality work.

2. QC PERSONNEL

a. How much time is available for or devoted to QC?

While roofing was being performed, the QC was on the roof approximately 90 percent of the time.

b. How much training has the QC person had in roofing QC?

Has had experience installing many roofs, several of which were for the Government.

c. What QC practices are followed on this job?

Submittals are made as specified in the contract; no checklist is used for QC.

d. Are job specifications readily available, and is the QC familiar with them?

Since he is the Construction Superintendent, he is familiar with all requirements and has them in his office at all times.

e. Concerning enforcement functions:

(1) What responsibility does he have for QC?

As the Construction Superintendent, he has full authority to enforce any measures he deems necessary to make the subcontractor comply with the specifications.

(2) How does he interact with the QA staff?

Since QA is performed by the Resident Engineer, all contact is directly at that level of responsibility. Relations are good between him and the QA staff.

f. Concerning roofing problems of this project:

(1) What specification requirements are most difficult to comply with?

Most trouble is with application methods.

- The requirement for same day application of aggregate actually hinders roofing production. It would be better to glaze at the end of each day and then apply all aggregate at one time.
- Where sheet metal is required, the contractor should be allowed to install temporary flashings as he proceeds, and then install all sheet metal at one time.
- Industry standards on EVT should be used instead of a specified maximum.
- The contractor should have the option to nail the entire first layer of insulation to the deck rather than use adhesive.

(2) What difficulties exist in interaction with the QA staff?

Most difficulties occurred during the preparatory inspections, over interpretation of the specification requirements. Once these were settled, all parties understood the requirements.

(3) What is recommended to minimize roof failures?

Closer control of steel fabrication is needed to accomplish desired roof contours.

g. Are the drawings and specifications detailed enough for the QC's purposes in construction?

They are clear and easy to follow, but not necessarily correct.

3. FIELD OBSERVATIONS

None. The roof had been completed before the site visit.

ANNEX 2: SPECIFIC RESPONSES TO QUESTIONS—SITE 4

1. RESIDENT ENGINEER STAFF

a. Concerning contract and roof details:

(1) What is the experience of the roofing contractor?

Has performed many large construction projects.

(2) Who actually performs the CQC?

The Construction Superintendent of the General Contractor, who has been with his company for 6 years. He has supervised several large jobs, but this is his first Government construction job. He has had no formal training in roofing, and his knowledge is limited to the content of the plans and specifications for the current project.

(3) What is the construction of the roof system?

Formboard on bar joists; gypsum concrete deck (1/4 in./ft [21 mm/m] slope). vapor barrier; insulation; four No. 15 asbestos felts, hot mopped in place; aluminum-pigmented top coating, reinforced with asbestos fibers.

(4) How adequate are the plans and specifications?

Drawings and specifications are clear and easy to follow. A discrepancy had been discovered in the roofing specification, in which a paragraph was titled "Asphalt Built-Up 5-Ply Asbestos Roofing" but the paragraph specified that three plies should be installed. The table of lap dimensions gave only the lap for five-ply roofs. An amendment to the contract was issued which equalized the title, the paragraph, and the table at four plies.

b. Concerning QC and QA procedures:

QC was performed by the Field Superintendent of the General Contractor; QA was performed by the Resident Engineer, who had no inspectors at the time.

(1) What comments would the Resident Engineer have concerning contractor's QC plan?

The plan was considered satisfactory. It included a list of items to be checked, submittals to be made, and a sample of the daily QC report.

(2) Was there a preconstruction conference? What was discussed?

In addition to the normal preconstruction conference for the entire job, which was devoted mainly to the CQC plan, safety plan, insurance, and other legal matters, a special preconstruction conference was held for roofing. All technical requirements were reviewed with both the General and the Roofing Subcontractor. Specific items addressed were:

- Inspection of the work area to insure that all preliminary work was completed.
- Review of all submittals.
- A check to insure that all materials had been approved.
- Review of plans and specifications, which included a careful search for discrepancies.

(3) Who conducts the initial, interim, and final job inspections?

Initial inspection of roof decks is performed as part of the preconstruction conference. Interim inspections are performed daily, and reported on the daily QC form. The Resident Engineer turns in

a daily QA report on a form developed for that purpose by the District Office in charge of the project.

(4) How are materials submitted for approval?

The QC submits these to the QA on standardized forms specified in the contract.

(5) Are daily QC/QA reports or log books required?

The contract requires a daily report from the QC. The format for this report was submitted by the General Contractor as part of the CQC plan. This report is given to the QA (in this case the Resident Engineer), who submits his own report on a QA form developed by the District Office.

(6) What equipment and tests are required?

No tests are specifically required. Asphalt maximum temperature is specified for both vapor barrier and built-up roof application, and a hand-held thermometer is used to verify this.

(7) Are checklists used by the QC inspector?

No checklists are required by the Resident Engineer's office, and none are used by the QC.

c. Concerning Resident Engineer responsibilities:

(1) What interaction does the Resident Engineer have with QC personnel?

Since the Resident Engineer performs the QA himself, he is in daily contact with the QC, which eliminates the loss of time and detail which could result from their interacting through a third person.

(2) What are the Resident Engineer's enforcement functions in QC/QA?

The Resident Engineer has a letter of authorization as Contracting Officer's Representative (COR). This letter directs him to issue "instructions to the Contractor affecting the performance of contractor work," which he feels gives him complete authority to act within the limits of the contract specifications. He cannot authorize changes; those must be issued by the Contracting Officer.

(3) Does the Resident Engineer experience any pressure from superiors for meeting job deadlines?

The Area Engineer, to whom the Resident Engineer reports, is primarily concerned with the quality of the work, and is constantly requiring careful attention to CQC and QA. The using agency had been pressuring for completion, but was quiet at the time of the visit, since the job was ahead of schedule.

(4) Does the Resident Engineer receive adequate support from the Contracting Officer in the decision of contract violations?

No disagreements ever had to go to the Contracting Officer for his decision, but the Resident Engineer was certain he would receive proper support if it were required.

(5) What is the Resident Engineer's philosophy and procedure in issuing job stop-orders?

Although he would not hesitate to shut the job down if it were necessary, this action was never required.

(6) What personnel are available for QA?

The Resident Engineer has a staff of three people to accomplish seven jobs. He is the only one who has taken the General Inspectors Training Course, and therefore performs the QA function himself.

(7) What funds are available for QA?

No extra funds are available. QA must be performed by the regular staff.

d. What problems have occurred during this particular construction?

Roofing work to date had been performed satisfactorily.

2. QC PERSONNEL

a. How much time is available for or devoted to QC?

Due to the scope of the project, the QC was unable to spend more than 25 percent of his time on

the roof. He had to rely to a great extent on daily required reports from his subcontractors. Other QC personnel made hourly checks.

b. How much training has the QC person had in roofing QC?

The QC has had no formal training in roofing. His knowledge is limited to the current project's plans and specifications.

c. What QC practices are followed on this project?

Submittals are made as specified in the contract. There is no formal written checklist, but one is developed as the job progresses.

d. Are job specifications readily available and is the QC familiar with them?

Since he is the Construction Superintendent, he is familiar with all requirements and has them in his office at all times.

e. Concerning enforcement functions:

(1) What is the QC's responsibility?

As the Construction Superintendent, he has full authority to enforce any measure he thinks is necessary to make the subcontractor comply with the specifications.

(2) How does the QC interact with the QA staff?

Since the Resident Engineer performs QA, all contact is directly at his level of responsibility. Relations are good between him and the QA staff.

f. Concerning problems with roof construction on this project:

(1) What specification requirements are most difficult to comply with?

- The requirement for daily installation of sheet metal is the most difficult. The fibrous aluminized coating takes at least 1 week to cure to a point where it can be walked on; when sheet metal and roof topping are installed at the same time, the topping sustains damage from workmen's shoes.

- The use of a handrail, which is really a safety problem, seriously affects the work. Roofing and sheet metal work cannot proceed at the edge when the handrail is in place, and therefore it must be removed. If it is reinstalled, it creates problems to the completed roof.

(2) What difficulties exist in interaction with the QA staff?

Most problems arise over safety requirements. There is no difficulty with QA, since the specifications are straightforward.

g. Are the drawings and specifications detailed enough for the QC's purposes in construction?

They are clear and easy to follow. Discrepancies were identified at the preconstruction conference and were eliminated by change-orders.

3. FIELD OBSERVATIONS

None. One building had been completed prior to the visit, and the next, although ready, had not yet been started because of inclement weather.

APPENDIX C:
SAMPLES OF DAILY CONTRACTOR QUALITY CONTROL REPORT FORMS

Sample #1

DATE

RECORD NO

QUALITY CONTROL RECORD

PROJECT NO. _____ BLDG. NO. _____

WEATHER (DESCRIBE) _____ AVERAGE TEMPERATURE _____

ROOFING CREW START _____ A.M. P.M. STOP _____ A.M. P.M. QUALITY CONTROLLER START _____ A.M. P.M. STOP _____ A.M. P.M.

TOTAL ROOF AREA (SQUARES) _____ PREVIOUSLY COMPLETED _____ COMPLETED TODAY _____ TEST SAMPLES REMOVED _____

PRODUCTS – SEE PROJECT SPECIFICATIONS – (CHECK APPROPRIATE BOX BELOW)				EXECUTION – SEE QUALITY CONTROL GUIDE – (CHECK APPROPRIATE BOX BELOW)							
COMPONENTS (Type, Quantity, Size)	Complies	Varies	Not Applicable	WORK ITEM	Complies	Varies	Not Applicable	WORK ITEM	Complies	Varies	Not Applicable
UNDERLAYMENT				1				13			
INSULATION				2				14			
MEMBRANE				3				15			
COMPO. FLASHING				4				16			
SHEET METAL				5				17			
FASTENERS				6				18			
WOOD				7				19			
SEALANTS				8				20			
EXPANSION JOINTS				9				21			
ALL OTHER MATERIALS				10				22			
				11				23			
				12				Others			

EXPLAIN VARIANCE (IF NONE WRITE "NONE")

UNRESOLVED VARIANCES ON RECORD NOS. _____

ACTION TAKEN TO RESOLVE VARIANCE

I CERTIFY THAT I HAVE PERSONALLY PERFORMED THE REQUIRED TESTS AND MEASUREMENTS AND ATTEST THAT THIS Q.C. RECORD IS AN ACCURATE RECORD OF ALL WORK ACCOMPLISHED TODAY.

QUALITY CONTROLLER _____ SIGNATURE

RECEIVED BY _____ SIGNATURE DATE _____

AF Form 1063 Test
APR '78

(Sample of typical Contractor Quality Control Report)

CONTRACTOR'S NAME
(Address)

DAILY CONSTRUCTION QUALITY CONTROL REPORT

Date:_____Report No._____

Contract No.:_____

Description and Location of work:_____

WEATHER: (Clear) (P. Cloudy) (Cloudy); Temperature:_____Min._____Max;
Rainfall_____inches.

Contractor/Subcontractors and Area of Responsibility with Labor Count for Each

a.

b.

c.

d.

Equipment Data: (Indicate items of construction equipment, other than hand tools, at the job site, and whether or not used.)

1. Work Performed Today: (Indicate location and description of work performed. Refer to work performed by prime and/or subcontractors by letter in Table above.)

2. Results of Surveillance: (Include satisfactory work completed, or deficiencies with action to be taken.)

   a. Preparatory Inspection:

   b. Initial Inspection:

   c. Follow-up Inspections:

3. Test Required by Plans and/or Specifications Performed and Results of Tests:

4. Verbal Instructions Received: (List any instructions given by Government personnel on construction deficiencies, retesting required, etc., with action to be taken.)

5. Remarks: (Cover any conflicts in plans, specifications, or instructions or any delay to the job attributable to weather conditions.)

6. Safety Violations (EM 385-1-1 and approved Safety Program) and Corrective Action Taken:

Contractor's Inspector

CONTRACTOR'S VERIFICATION: The above report is complete and correct and all material and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications except as noted above.

Contractor's Approved Authorized Representative

R. N. ROUSE & COMPANY, INC.
1019 N. WILLIAM STREET
GOLDSBORO, NORTH CAROLINA

CONSTRUCTION QUALITY CONTROL REPORT

Contract No. DACA21-78-C-0021 Date _____ Report No. _____

WEATHER:
Temperature: _____ min.; _____ max.

Rainfall:

CONTRACTOR/SUBCONTRACTORS AND AREA OF RESPONSIBILITY

_____

_____

_____

_____

_____

_____

_____

DESCRIPTION & LOCATION OF WORK PERFORMED TODAY: _____

_____

_____

_____

_____

_____

_____

_____

RESULTS OF SURVEILLANCE: _____

_____

_____

TESTS REQUIRED BY PLANS AND/OR SPECIFICATIONS PERFORMED AND RESULTS OF TESTS

VERBAL INSTRUCTIONS RECEIVED:

REMARKS:

Inspector

CONTRACTORS VERIFICATION:

The above report is complete and correct and all material and equipment used and work performed during this report period are in compliance with the contract plans and specifications except as noted above.

Quality Control Officer

J. W. DOWELL CONSTRUCTION COMPANY, INC.
561 CEDAR AVENUE, N. W.
ATLANTA, GEORGIA 30318 (404) 799-0251

CONSTRUCTION QUALITY CONTROL REPORT

DATE: _____ REPORT NO._____

CONTRACT No.:_____

Description and location of Work:_____

Weather: (Clear) (P. Cloudy) (Cloudy); Temperature:___Min,___Max; Rainfall___In.

CONTRACTOR/SUBCONTRACTORS AND AREA OF RESPONSIBILITY

A. _____
B. _____
C. _____
D. _____
E. _____
F. _____
G. _____

1. Work performed Today:

_____

2. Results of Surveillance:

_____

3. Tests Required by Plans and/or Specifications Performed and Results of Tests:

SANTA FE ENGINEERS, INC.
P.O. BOX

CONTRACTOR DAILY CONSTRUCTION QUALITY CONTROL REPORT

PROJECT: _____ JOB NO. _____

LOCATION: _____ CONTRACT NO. _____

DATE _____ 19 _____ REPORT NO. _____

WEATHER: _____ TEMP: _____ MAX: _____ RAINFALL_____INCHES

		WORK FORCE												
		A	B	C	D	E	F	G	H	I	J	K	L	M
A. Santa Fe Engineers, Inc.	Contr.													
B. _____	Sub.													
C. _____	Sub.													
D. _____	Sub.													
E. _____	Sub.													
F. _____	Sub.													
G. _____	Sub.													
H. _____	Sub.													
I. _____	Sub.													
J. _____	Sub.													
K. _____	Sub.													
L. _____	Sub.													
M. _____	Sub.													
	TOTALS													

1. Work performed today: Indicate location and description, (refer to work performed by prime and subcontractors by letter indicated above).

2. Result of inspection of work in progress today: (Include satisfactory work done and deficiencies, including safety, and any action taken).

3. Tests performed today: (Name and location of tests) Test results on separate sheet.

4. Verbal instructions received from government personnel: (List instructions given and indicate name or names.)

5. Delays and delaying factors, (Weather, strikes, material, etc.) Indicate extent, type of work, number of men involved. If no delay, indicate.

6. Materials and equipment delivered to jobsite today.

7. Remarks: Cover any conflicts or ommissions noted this date in plans, specifications, or instructions from government employees:

Contractor's Quality Control Supervisor

VERIFICATION: The above report is complete and correct and all material and equipment used and work performed today are in compliance with the contract plans and specifications except as noted above.

DATE

Contractor's Authorized Representative

REFERENCES

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Lindow, Edward S
Built-up roof construction quality control / by E. S. Lindow ... (et al.). -- Champaign, IL : Construction Engineering Research Laboratory ; Springfield, VA : available from NTIS, 1979.
39 p. : ill. ; 27 cm. (Technical report ; M-267)

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